Title: **Improving Rooting of Pinyon Pine Seedlings by Using Naphthaleneacetic Acid Treatments**

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FINAL STATUS OF THE PROJECT

Abstract:

Pinyon pine (*Pinus edulis*) is a native plant species whose seedlings can be difficult to transplant if harvested as bareroot plants, but an auxin treatment applied to plant roots may improve rooting and ultimately seedling survival. The objective of this study was to determine if naphthaleneacetic acid (NAA) could be used to improve root regeneration on bareroot seedlings of pinyon pine. Bareroot seedlings (2-0) of pinyon pine were treated with 0, 1000, 2000, 4000, or 8000 ppm NAA by soaking for 5 seconds before planting in a gravel bed or field soil. Seedlings were grown for 26 weeks before plants were harvested. At harvest, increases in shoot heights, average stem diameters, root volumes as well as root and shoot dry weights were determined. By the end of the study only 28.3% of the seedlings in the field survived, whereas only 16.7% of the plants in the gravel bed survived. Statistical analyses showed that neither the type of planting bed or NAA treatments affected seedling survival. The type of planting bed (soil versus gravel) and auxin treatments failed to affect seedling height increases, stem diameters, root volumes, shoot dry weights, and root dry weights. This study demonstrated that bareroot pinyon pine seedlings were quite difficult to transplant into field or gravel beds and that naphthaleneacetic acid treatments were ineffective for promoting root formation on the seedlings.

Materials and Methods:

The experiment, improving rooting of pinyon pine (*Pinus edulis*) seedlings by using naphthaleneacetic acid treatments, was begun in April 2007. Bareroot 2-0 seedlings were planted in a gravel bed or directly into the field. Before planting, field soil was amended with compost (~0.75 yd^3 incorporated 6 inches deep in the 12 ft. by 10 ft. plant bed). Roots of the seedlings were trimmed to 17 cm (6.5 inches) from the root/stem interface and treated with 0, 1000, 2000, 4000, or 8000 ppm naphthaleneacetic acid (potassium salt) by soaking for 5 seconds before planting. Seedlings were planted in the soil or gravel beds in four blocks of five randomized treatments with six replications (plants) per treatment. The blocks were partitioned by guard rows of seedlings. Thirty seedlings were planted per block with a total of 120 trees per medium (gravel or soil). Seedlings were planted in the gravel bed April 11 and shaded with 55% shade

cloth May 22. The field seedlings were planted April 13 and shaded with 55% shade cloth May 28.

Seedlings were watered by a micro-emitter irrigation system with spray stakes. The gravel bed system was automated with water applied every other day, but watering was increased to every day during hot weather. The field seedlings were irrigated by manual operation of the microsystem and watered when soil was sufficiently dry (about twice a week). Seedlings in both the field and gravel beds were fertilized once a week starting July 13 and ending September 1. The fertilizer treatment was a solution of Peter's 30-10-10 fertilizer applied at a rate of 100 ppm N.

On October 9 and 11, pinyon pine seedlings were dug in the field bed and gravel bed, respectively. Seedlings were considered to have survived transplanting if they produced new root growth. After digging, the root systems were rinsed with tap water, and the length of the new (2007) growth produced by each seedling's main leader was measured. The root-stem collar sections of seedling trunks were measured twice at 90 degrees from each other to provide the average stem diameter. Root volume was determined by noting the amount of water a seedling's root system would displace when the roots were submerged in a graduated cylinder. Shoots were cut from the root systems at the root collars for all live seedlings, and then roots and shoots were placed in separate paper bags and placed in a drying oven at 43°C for at least two weeks until the tissues were completely dry.

Two types of statistical analyses were used to determine if the type of growth medium (gravel or soil) and the NAA treatments affected seedling survival and growth. Seedling survival was categorical data, and survival percentages were analyzed by Chi-square analysis (Proc GENMOD in SAS). Analysis of variance was used to determine if growth medium or NAA treatments affected seedling height growth, average stem diameter, root volume, root dry weight, and shoot dry weight. The overall probability needed to show significant growth medium or NAA treatment effects had to be at or below the 5% level ($P \leq 0.05$) when completing statistical analyses. Determining significant differences between treatment means (growth medium effects, NAA concentration effects, and their combinations) were unnecessary since both main effects failed to influence seedling survival or growth.

Results and Discussion:

The naphthaleneacetic acid treatments failed to promote root regeneration and survival of pinyon pine seedlings either in the gravel bed or field soil. By 26 weeks after planting, only 28.3% of the seedlings in the field survived, whereas only 16.7% of the plants in the gravel bed survived. Statistical analyses showed that neither the type of planting bed ($P = 0.066$) nor the NAA treatments ($P = 0.735$) affected seedling survival. An interaction between the planting bed and NAA treatments was also absent ($P= 0.273$). Although 14 more plants survived in the field bed compared to the gravel bed (Table 1), the statistical model indicated that the planting bed lacked an effect on seedling survival.

We are unsure why more bareroot seedlings transplanted into soil survived compared to those grown in the gravel bed since in previous years bareroot seedlings of pinyon pine grown in

gravel survived in higher numbers than those grown in soil. Perhaps the field soil has been improved over the recent years due incorporating compost into the soil (a request made by the nursery industry). Perhaps seedlings grown in soil were better cared for than in past years, and the improved care resulted in higher survival percentages of bareroot pinyon pine seedlings grown in soil than in past years. Finally, shading bareroot pinyon pine seedlings in the gravel bed may have caused the gravel mixture to retain too much water, which in turn reduced seedling survival. Perhaps one or more of these factors contributed to lower survival percentages of bareroot pinyon pine seedlings in gravel compared to soil.

For the seedlings that survived, their root and shoot growth were unaffected by planting bed and NAA treatments (Table 1). Statistical models for mean height increase ($P = 0.575$), mean stem diameter ($P = 0.600$), mean root volume ($P = 0.429$), mean shoot dry weight ($P = 0.528$), and mean root dry weight ($P = 0.896$) lacked significance. Only a little new growth formed on seedling roots and shoots, regardless if the plants were grown in soil or gravel (based on visual observations). For example, the mean height increase of all surviving seedlings was 0.63 cm (about ¼ inch) across all NAA treatments and growth media (gravel and soil). The lack of seedling growth indicated that the seedlings were stressed and had difficulty surviving transplanting.

In general, pinyon pine seedlings survived poorly regardless of whether they were grown in soil or gravel or their roots were treated with NAA. Minimal root and shoot growth indicated the seedlings that survived were stressed even though they were treated with different concentrations of NAA. The growth regulator treatments were intended to improve root formation but failed as indicated by non-significant changes in root volume and mean root dry weight as NAA concentrations changed (Table 1). Overall, the NAA treatments failed to promote root formation thereby failing to improve seedling survival.

Significance to the Nursery Industry:

Based on this year's (2007) research with 2-0 pinyon pine seedlings, bareroot plants survived at similar low levels in a gravel bed or field soil. When considering the 2007 study with previous years' research, bareroot pinyon pine seedlings have poor survival after being harvested at the seedling nursery. Two types of auxin, indole-3-butyric acid and naphthaleneacetic acid, shading, and planting in a gravel bed have failed to improve survival percentages higher than about 30%. This level of plant mortality (70%) is unacceptable for specimen tree producers of conifers. In contrast, the 2006 research project that used plug plants of pinyon pine seedlings demonstrated that 85% or more of the container plants survived when transplanted into gravel or soil. Therefore, pinyon pine seedlings grown in containers should be used by specimen conifer growers since the containerized root systems provide a strong advantage for this difficult-to-transplant species. One major drawback to using container grown seedlings is that they usually cost over four times more than bareroot pinyon pine plants. Lower transplant survival rates of bareroot plants, however, dictate that container seedlings be used due to their high survival rates.

Table 1. Number of surviving plants and mean height growth, stem diameter, root volume, shoot dry weight and root dry weight of pinyon pine seedlings grown in field soil or a gravel bed.

Growth medium	NAA concentration (ppm)	Initial number of plants	Number of surviving plants	Mean height growth (cm)	Mean stem diameter (mm)	Mean root volume (cm^3)	Mean shoot dry weight (g)	Mean root dry weight (g)
Field soil	0	24	6	0.9	5.0	5.3	5.9	1.7
	1000	24	11	0.6	5.0	5.3	5.7	1.6
	2000	24	7	0.5	4.8	5.6	5.0	1.6
	4000	24	7	0.8	4.8	6.0	5.4	1.6
	8000*	24	3	0.6	5.4	11.3	6.6	2.5
Gravel bed	0	24	7	0.8	4.5	3.1	5.5	1.3
	1000	24	4	0.7	4.7	4.0	4.6	1.3
	2000	24	6	0.6	4.9	5.2	5.5	1.8
	4000	24	3	0.2	4.4	3.3	4.2	1.3
	8000*	24	0	—	—	—	—	—

* Plant survival and growth data for seedlings treated with 8000 ppm NAA were excluded from analyses due to their low overall survival percentage.